

# AFOSR Nobel Prize Laureates

## The Air Force Office of Scientific Research creates a legacy of Nobel Prize-winning research.

*AFRL's Air Force Office of Scientific Research, Arlington, VA*

Beginning in 1955 and continuing to the present, the Air Force Office of Scientific Research (AFOSR) sponsored 46 Nobel Prize laureates—38 of whom were funded prior to winning the Nobel Prize.



Figure 1. Dr. Charles Townes

One of the most highly coveted and recognized awards, the Nobel Prize, recognizes those who contribute significant achievements in the areas of physics, chemistry, physiology or medicine, literature, peace, and economic sciences. The Nobel Foundation was established in 1900 and in 1901 the Nobel Prize became the first international award to be given on an annual basis. Established as outlined in his last will and testament, Dr. Alfred Nobel stated, "...the whole of my remaining realizable estate shall be dealt with in the following way...annually distributed in the form of prizes to those who, during the preceding year, shall have conferred the greatest benefit to mankind."

AFOSR funded 26 Nobel Prize laureates in physics, 14 in chemistry, and 6 in physiology and medicine. The selection of Nobel Prize laureates and their respective prize citations readily demonstrates the astute ability of AFOSR program managers to choose world-class researchers to readily address Air Force (AF) requirements and advance AF programs.

AFOSR-funded research created many breakthroughs in the area of physics. Drs. Polykarp Kusch and Wills Eugene Lamb shared the 1955 prize for work in "precision determination of the magnetic moment of the electron" and "discoveries concerning the fine structure of the hydrogen spectrum." The early research by these two winners resulted in the development of techniques for microwave interaction with atoms and atomic beams. One important application to the AF, and increasingly within civilian economy, is the cesium

beam atomic clock, an essential part of the Global Positioning System (GPS). Without the incredibly accurate time-keeping capabilities of atomic clocks, the GPS would not be possible.

In 1964, AFOSR sponsored the research of Dr. Charles Townes (see Figure 1) who won the prize for his "fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers

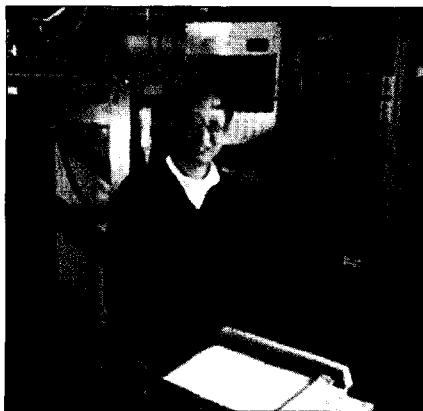


Figure 2. Dr. Daniel Tsui

based on the maser-laser principle." Dr. Townes' credits include inventing the maser, a device that amplifies electromagnetic waves. This technology paved the way for sensitive reception of communications and precise navigation. It also provided basic components for its successor, the laser, which uses visible light. Many applications of the maser and laser are in radar, communications, astronomy, navigation, atomic clocks, and surgery. (See article, page 14.)

In 1972, Dr. John Bardeen received his second Nobel Prize in physics and shared this award with two others for their "theory of superconductivity, usually called the BCS theory." Dr. Bardeen is the first scientist to win two Nobel Prizes in the same category. His first prize in 1956 was for the "coinvention of the transistor," a tiny electronic device capable of performing most of the functions of a vacuum tube, but far smaller and using much less energy. The transistor became the building block for all modern electronics and the foundation for the microchip and computer technology.

In 1981, Professor Nicolaas Bloembergen (AFOSR-funded), Dr. Arthur Schawlow, and Dr. Kai M. Siegbahn were corecipients for their "contribution to the development of laser spectroscopy." Prof. Bloembergen's contributions to nonlinear optics and spectroscopy advanced

both nonlinear theory and development of instrumentation. His findings led directly to significant advances in non-contact, non-destructive evaluation. The development of laser ultrasonic systems provides damage detection of aging aircraft structures and engine components without physical contact, resulting in huge aircraft maintenance savings.

AFOSR also sponsored Dr. Daniel Tsui (see Figure 2) who won his prize in 1998. Dr. Tsui received his award for fractional quantum hall effect research for the "discovery of a new form of quantum fluid with fractionally charged excitations." Dr. Tsui's discoveries set the stage for miniaturized, high-performance, millimeter-wave components used extensively in surveillance and communication systems. These faster, smaller components may help the AF achieve its goals of 75-80% weight/volume reductions in electronic circuits early in the next century.

In 2000, AFOSR supported Dr. Herbert Kroemer (see Figure 3) who was cowninner of the Nobel Prize in physics for his work in "developing semiconductor

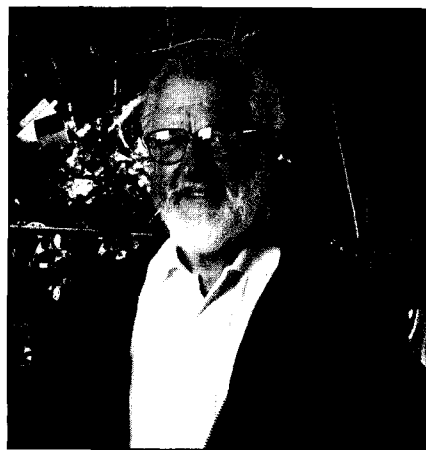


Figure 3. Dr. Herbert Kroemer

heterostructures used in high-speed and opto-electronics." Dr. Kroemer was the first to propose the use of thin layers of semiconducting materials, known as heterostructures—novel composites of two or more materials, to develop the heterostructure transistor. The new transistor made significant improvements over conventional transistors in current amplification and high-frequency applications. AFOSR supported Dr. Kroemer's work in semiconductors from 1995 through 2000. As a result, radio link satellites, the Internet, mobile phones, and compact

disk players all use heterostructure technology.

In the area of chemistry, AFOSR backed the research of 1966 Nobel laureate Dr. Robert Mulliken for his "fundamental work concerning chemical bonds and the electronic structure of molecules by the molecular orbital method." Dr. Mulliken was one of the early leaders in developing methods in computational chemistry. His work led to development of computer codes, which have real predictive capabilities and are used widely throughout the Department of Defense. Dr. Mulliken developed methods that enable calculations of many molecular properties including molecular geometries and structures. Scientists routinely use these models to guide in the synthesis of new compounds, fuels, and propellants.

From 1962 to 1964, AFOSR funded Dr. Donald Cram's research. As a corecipient in 1987, Dr. Cram received the Nobel Prize in chemistry for the "development and use of molecules with structure-specific interactions of high selectivity." Dr. Cram developed what is known today as the "host-guest chemistry." This work involves creating synthetic host molecules that mimic some of the actions enzymes perform in cells. These molecules control chemical reactions in medicines and deliver active ingredients in controlled dosages long after medicine is taken.

Dr. Ahmed Zewail (see Figure 4) won the Nobel Prize in chemistry in 1999. Dr. Zewail was "recognized for his pioneer-



Figure 4. Dr. Ahmed Zewail

ing efforts using ultra-short laser flashes to monitor chemical reactions." In 1986, AFOSR supported the establishment of the initial femtosecond facility used to perform the winning work. Dr. Zewail's ultra-fast lasers capture chemical reactions of atoms and molecules as bonds form and break during a reaction. This area of physical chemistry is named femtochemistry. Dr. Zewail's technique uses laser flashes of such short duration that these chemical reactions occur in real time. His cutting-edge insights helped scientists understand how certain molecules are synthesized, how energy is re-

leased in reactions, and how to control the outcome of chemical reactions.

The most recent AFOSR-supported prizewinner for chemistry in 2000 is Dr. Alan Heeger (see Figure 5) for "the

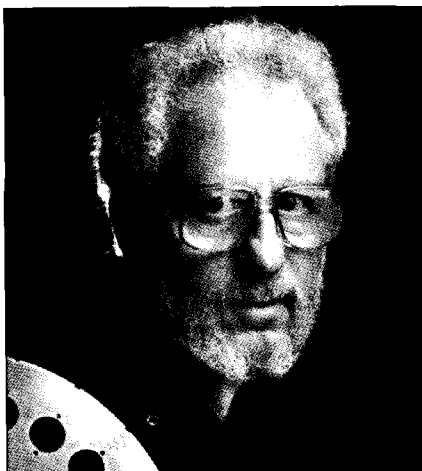


Figure 5. Dr. Alan Heeger

discovery and development of conductive polymers," arguably the most important chemical discovery in modern times. Dr. Heeger played a critical role in creating a plastic that conducts electricity like a metal. In the late 1970s, Dr. Heeger, along with two associates, began fundamental research in conductive polymer plastics. The research team found that a thin film of polycetylene, when oxidized with iodine vapor, exhibited an electrical conductivity increase of a billion times, turning an insulator to a conductor. This discovery opened up a new field of carbon-based electronics with wide applications and benefits. AFOSR funded Dr. Heeger's work continuously since 1988.

In the area of physiology and medicine, AFOSR funded Dr. Ragnar Granit's research on the electrical properties of neurons in 1959. As a result of this pioneering research, Dr. Granit was a cowinner of the Nobel Prize in 1967 for his "discoveries concerning the primary physiological and chemical visual processes in the eye." Today, engineers use Dr. Granit's work in electrical signals of brain nerve cells to assess cognitive workloads under a variety of conditions affecting individual performance. Engineers also use his methods for determining functional properties for networks of nerve cells to develop more effective designs for analog computers and nonlinear dynamic control systems.

In 1981, Drs. David Hubel and Thorsten Wiesel received the Nobel Prize in physiology and medicine. Recognized for their "discoveries concerning information processing in the visual system," Drs. Hubel and Wiesel established the basic architecture for how the brain analyzes visual patterns. Their

work strongly influenced the direction of other work in sensory physiology especially in the studies of somatosensory mechanisms, audition, and the coordination of movement. Computer algorithms incorporating similar analysis and logic are now a mainstay of automatic systems for image and speech recognition.

In 2000, another AFOSR-funded researcher was recognized for his work. Dr. Paul Greengard (see Figure 6) received the Nobel Prize for physiology

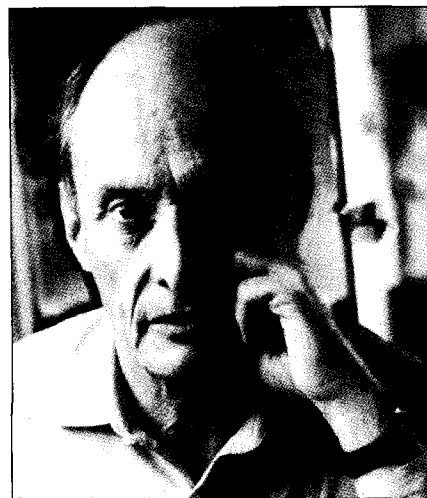


Figure 6. Dr. Paul Greengard

and medicine for his work in "signal transduction in the nervous system." The Nobel Foundation recognized Dr. Greengard's research for discoveries of synaptic transmission mechanisms between human nerve cells. Dr. Greengard's research began over three decades ago and demonstrated how chemicals, known as neurotransmitters, carry signals between nerve cells. These findings resulted in the understanding of how brain processes function and in the development of drugs. AFOSR supported Dr. Greengard's research in neurotransmission from 1984 to 1987.

For one hundred years, Nobel Prize laureates have been the recognized leaders in their respective fields, accomplishing research at the very edge of the frontiers of science. AFOSR is extremely proud to have sponsored 46 Nobel Prize laureates. Due, in part, to the remarkable scientific contributions of these Nobel laureates, the United States AF maintains a significant advantage on the battlefield. For the past fifty years, AFOSR has been instrumental in creating a legacy of Nobel Prize-winning research.

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